891

mi Sanders

A GEC-MARCONI ELECTRONICS COMPANY

6423

tft

POWER HEAD

INSTRUCTION MANUAL

MARCONI INSTRUMENTS LTD
SANDERS DIVISION STEVENAGE

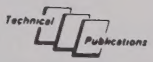
MP MASTER
MA23609

INSTRUCTION MANUAL

for

TYPES 6423

tft POWER HEADS



©
1973

MARCONI INSTRUMENTS LIMITED
SANDERS DIVISION
STEVENAGE HERTFORDSHIRE ENGLAND
A GEC-MARCONI ELECTRONICS COMPANY

CC 130/SP
8/73/B

CHAPTER 1 General Information

1.1 GENERAL DESCRIPTION 1

CHAPTER 2 Operation

2.1. OPERATING INSTRUCTIONS 2
2.2 CAUTION 3

CHAPTER 3 Technical Description

3.1 DESIGN DETAILS 4
3.2 SOURCES OF ERROR 4

CHAPTER 4 Maintenance

4.1 GENERAL MAINTENANCE 8
4.2 REPLACEMENT OF ELEMENTS 8
4.3 REPLACEMENT OF THERMISTOR ASSEMBLY 12
4.4 CALIBRATION 14

CHAPTER 5 Replaceable Parts

FIGURES

Figure 1 7
Figure 2 9
Figure 3 16
Figure 4 17

ADDENDUM

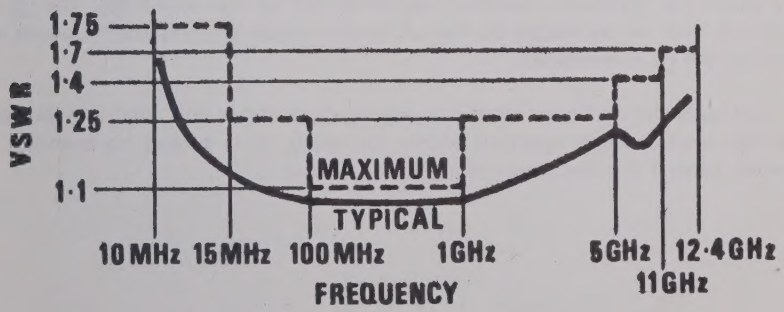
No. 1 LOW FREQUENCY VERSIONS 20

Chapter 1

General information

1.1 GENERAL DESCRIPTION

Type 6423 is a coaxial tft(R)* Power Head designed for the measurement of radio frequency signals over an extremely wide range of power and frequency.** This unit is intended for use with the MI/Sanders Type 6460 and 6550B Thermoelectric Power Meters and will measure amplitude and frequency modulated as well as CW signals. The power range of the Coaxial tft Power Head when used with the Type 6460 extends from 300 μW on the most sensitive range to 3W full scale on the highest power range and from 10 μW when used with a Type 6550B. Lower powers can be measured using the MI/Sanders Type 6422 (up to 1 mW), Type 6420 (up to 10 mW) or Type 6421 (up to 100 mW). Frequency coverage extends from 10 MHz to 12.4 GHz for each of the models. In addition, waveguide models are available covering the 8.2 to 40.00 GHz frequency range.



* thin-film thermoelectric

** U.S.Patent 3,384,819

Chapter 2

Operation

2.1 OPERATING INSTRUCTIONS

To place the tft Power Head into use, first connect it to a tft powermeter and zero the instrument to balance out residual thermal e.m.f.s. (The detailed operating procedures for the Type 6460 and 6550B are given in the Operating and Service Manuals supplied with those instruments.) If automatic correction for effective efficiency is desired, interpolate the efficiency from the graph supplied with the mount and set the efficiency control at the rear of the mount to that number. It is reasonable to assume a smooth curve between the measured points. Each unit is measured on a swept basis over most of the band to ensure that there are no 'holes' over that range. If this is not convenient or desirable, set the control to 100% and correct the readings obtained by calculation. This procedure is in fact the more accurate of the two since manufacturing tolerances on parts and components result in a small error in the correction circuity. For effective efficiencies of 90% and with tft elements at the limits of acceptable sensitivity, this error can be as high as about 1%. Typically, however, the error will be less than 0.5%. The tft Power Head should then be connected to the r.f. system under test and the r.f. power will be indicated on the tft Powermeter.

Although the tft Power Head is a rugged, dependable unit, that will give reliable trouble-free service when operated within its rating, it is subject to burn-out when overloaded. Table 1 lists the power rating for the model.

Chapter 2

Operation

Table 1 – Power Ratings for tft Power Head

Model	Average Power, Continuous Duty	Max. Peak Pulse Power*	Max. D.C. Voltage
6423	3W	100W	50V

*Tentative Ratings for PRF's greater than 50 Hz
At lower frequencies this should be reduced.

While the tft Power Head will take overloads of up to 300% for short periods of time, extended periods of operation at this level or exceeding these ratings may result in permanent change in the tft element characteristics or even burn-out. Maximum care should be exercised to avoid its occurrence.

Chapter 3

Technical description

3.1 DESIGN DETAILS

The tft Power Head incorporates a thin-film metallic load which, acting as a well-matched termination, absorbs the incident r.f. power. The load consists of bismuth and antimony sections which are vacuum deposited on a thin dielectric substrate in a geometric configuration that produces a number of thermoelectric junctions. Some of the junctions are thermally 'sinked' to the transmission line while the remaining junctions are located in the air space between the lines. The absorbed r.f. power raises the temperature of these latter junctions relative to the 'sinked' junctions and thus a thermoelectric e.m.f. is generated proportional to the temperature rise. By keeping the temperature differential between the junctions small, the unit acts as a true square-law (r.m.s.) device producing a d.c. output voltage directly proportional to the absorbed power.

The tft Power Head is designed to be used with the MI/Sanders 6460, and 6550A which are equipped with the following special features:

3.1.1 Direct reading in power. No conversion required.
3.1.2 Automatic adjustment for each tft Power Head sensitivity factor.
3.1.3 Interlock circuitry to ensure proper scale selection.
3.1.4 Compensation circuits to correct for sensitivity factor temperature coefficient.
3.1.5 Shielded low-noise connector.

It may also be used with any other d.c. voltmeter that offers adequate sensitivity and accuracy. It is recommended that the factory be consulted on special instrumentation problems.

3.2 SOURCES OF ERROR

There are two primary sources of error that are common to most power measuring devices. These are best described by the terms mismatch and efficiency errors.

3.2.1 Mismatch errors

The ideal power sensing device should be completely reflectionless, absorbing all the power that is incident upon it. Although all models of coaxial tft Power Heads are very well matched over an extremely broad band of frequencies, there may still be a significant amount of power refelected at some frequencies, e.g. when the VSWR reaches the maximum rated value of 1.5, the power reflected to a matched source will be 4%.

In order to account exactly for the mismatch error, one must know the complex impedances of both generator and load. In most circumstances, it is not convenient to measure these quantities. Nevertheless, with a knowledge of the *magnitude* of these two quantities, it is possible to establish an upper bound on this error with the use of the following equation:

$$\text{Mismatch error} = \frac{(1 - |\Gamma_g|^2)(1 - |\Gamma_L|^2)}{(1 \pm |\Gamma_g \Gamma_L|)^2}$$

where Γ_g = the generator reflection coefficient.

Γ_L = the load reflection coefficient, and

$$\Gamma = \frac{\text{VSWR}-1}{\text{VSWR}+1}$$

Figure 1 is a graph of the limits of mismatch error as a function of generator and load VSWR.

3.2.2 Efficiency errors

Although the usual definitions of mount efficiency as applied to barretters and thermistors do not apply to tft Power Heads, since these devices do not depend directly upon substitution power to effect a measurement, an equivalent error exists which is a result of the frequency dependent response of the unit. As described below, calibration of the tft Power Heads can be performed at audio frequencies, and, in fact, this is one of the factory procedures employed.

Although ideally the Joule heating effect of the audio power used in calibration and r.f. power to be measured should be the same, thereby giving rise to the same thermoelectric e.m.f., in practice some of the r.f. power is absorbed by the mount is lost in the metallic conductors and dielectric supports of the mount as well as in the r.f. bypass capacitors and contacts of the tft element.

It is convenient to define the term effective efficiency for a tft Power Head as the ratio of the audio power to the total absorbed r.f. power required to produce equal d.c. output voltages from the power head. Each coaxial tft Power Head is tested at the factory for effective efficiency at the fixed frequencies of 1.0, 3.0, 6.0, 8.0, 10.0 and 12.4 GHz over most of the band on a swept frequency basis. The effective efficiency data obtained at the fixed frequencies is stamped on the metal graph mounted on the power head cover. All models of coaxial tft Power Heads have typical efficiencies of 99% at 1 GHz and are more than 85% efficient up to 12.4 GHz.

A systematic correction for mismatch error cannot be applied since, as stated above, it depends upon both mount and generator VSWR. However, efficiency errors can be corrected unambiguously if the operating frequency is known since this depends solely upon the mount characteristics. For this purpose, a control is provided at the rear of each coaxial tft Power Head calibrated directly in terms of effective efficiency. When this control is set to the measured or interpolated value of effective efficiency for the frequency in use. The Type 6460, and 6550B Thermoelectric Power Meters will automatically correct for and eliminate this error. Correction range extends from 85 to 100% on all models.

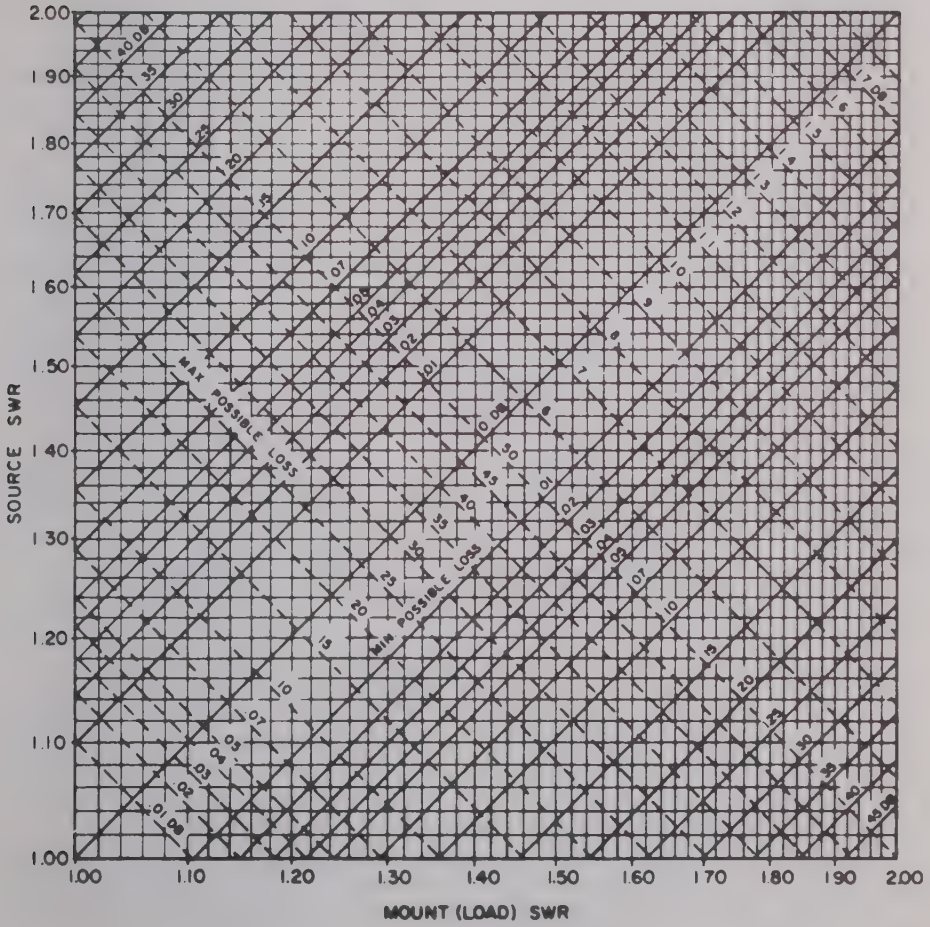


Fig.1. Mismatch Loss Limits

Chapter 4

Maintenance

4.1 GENERAL MAINTENANCE

Except for replacement of tft elements, maintenance should not be required for tft Power Heads.

4.2 REPLACEMENT OF ELEMENTS

To check the tft element, verify that the resistance between pins 1 and 3 on connector P1 is approximately 200 ohms. DO NOT USE R ÷100 OHMMETER RANGE.

When spare tft elements are required for field replacement, they should be ordered in accordance with the following:

Type No. tft Power Head	Type No. tft element
6423	TL–3

If factory replacement of tft elements is desired return the unit to the Service Dept, Marconi Instruments, Sanders Division, P.O. Box No.10, Stevenage, Herts. England SG1 2AU, with a request for service.

Referring to the exploded view, Fig.2, for parts identification, proceed as follows for field replacement of tft elements. It is recommended that MI/Sanders Tool Kit 3850–TK–1 be employed in the replacement procedure to prevent accidental damage to the tft elements.

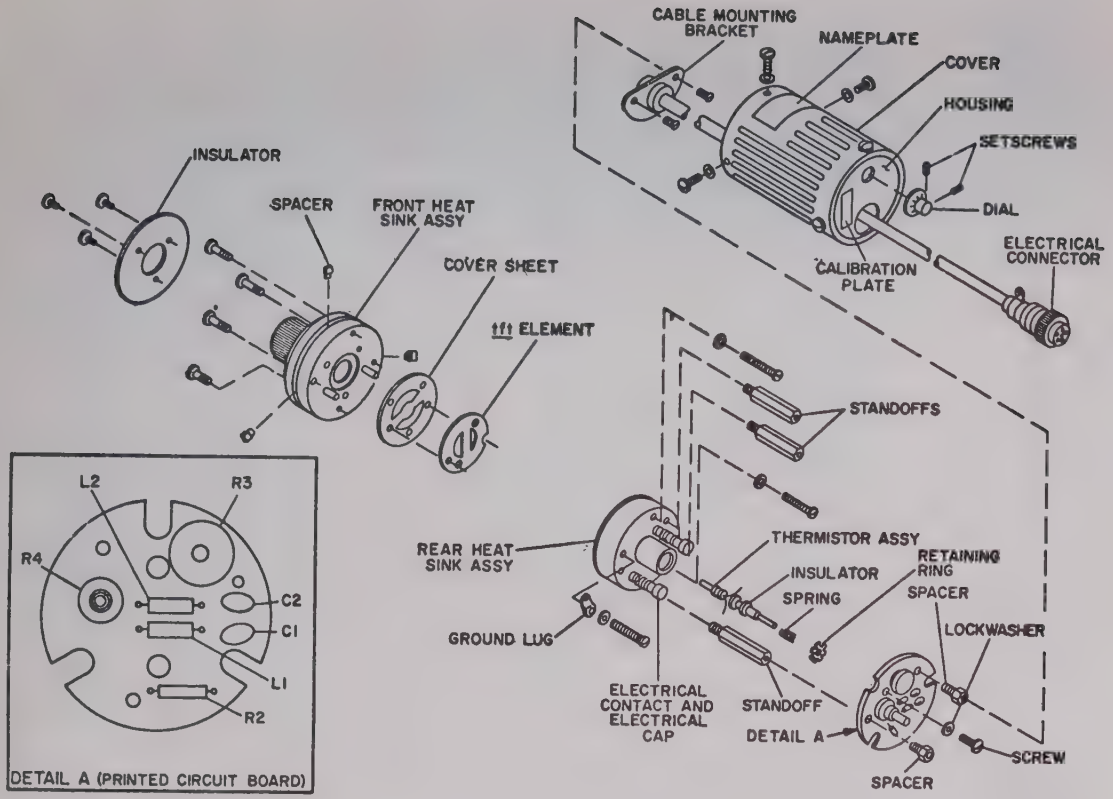


Fig. 2 Exploded View, Type 6423

4.2.1 At the front (Type N connector) end of the unit, remove the three screws and washers which secure the metal cover to the front heat sink assembly. (One or more of the three spacers mounted in the front heat sink assembly may come out at this time. Set them aside and replace them when reassembling the unit.)

4.2.2 Remove the dial from the dial control shaft.

4.2.3 Remove the three screws which secure the insulator to the front heat sink assembly, and remove the insulator.

4.2.4 Remove the four cap-screws which secure the housing to the front heat sink assembly. Slip the housing off the power head assembly until it is free on the cable.

CAUTION

Carefully perform the following step as indicated to avoid equipment damage. Ensure that the rear and front heat sink mounting surfaces are parallel to each other at all times until the assemblies clear each other.

4.2.5 Remove the rear heat sink assembly as follows:

4.2.6 Remove the three screws and washers which secure the rear heat sink assembly to the front heat sink assembly after noting the position of the ground lug.

4.2.7 Bring the rear heat sink assembly *straight back* until it clears the front heat sink assembly.

4.2.8 Remove the tft element and cover sheet after noting their orientation.

4.2.9 Clean the two heat sink mounting surfaces with a cotton swab, using acetone or another residue-free cleaning agent. After cleaning, inspect the two surfaces to determine that all foreign particles have been removed.

4.2.10 Inspect the new tft element and cover sheet. If any foreign particles are detected, carefully remove them with a dry swab. *Do not* clean with acetone. The tft element and cover sheet should be handled only at the edges with tweezers such as are included in MI/S Tool Kit 3850–TK–1.

4.2.11 Install the replacement tft element and new cover sheet over the pins of the front heat sink assembly with the same orientation as noted in step 4.2.8 above. Do not re-use the old cover sheet.

4.2.12 Although these parts will fit over the pins in several orientations, there is only one that will correctly align the centre of the element with the centre conductor on the front heat sink assembly.

4.2.13 See caution notice 4.2.4. Secure the rear heat sink assembly to the front heat sink assembly as follows:

4.2.14 Align the dowel pins on the front heat sink assembly with the corresponding holes in the rear heat sink assembly.

4.2.15 Slowly close the gap between the two assemblies until the point where the thermistor assembly protrusion contacts the tft element. Then carefully bring the two assemblies together.

4.2.16 Replace the ground lug and the three screws and washers, and finger-tighten them.

4.2.17 Tighten the three screws sequentially and uniformly one half turn at a time until sufficient torque is transmitted to firmly secure the two assemblies.

4.2.18 Reattach the Housing to the front heat sink assembly and secure.

4.2.19 Rotate the dial control shaft fully clockwise, set the dial to read 100% and secure.

Replace the insulator and secure.

4.2.20 After the power head has been reassembled, measure the resistance from pins 1 and 3 to ground using the RX100 range on the ohmmeter. It should read open circuit. If not, there is a short in the mount, which may be due to a foreign particle in the assembly. If this occurs, the mount should be disassembled, cleaned as described above, and reassembled.

4.2.21 Calibration of the unit is required after tft element replacement. Perform the procedures described in 4.4.3 below.

4.3 REPLACEMENT OF THERMISTOR ASSEMBLY

To replace the thermistor assembly (RT1), perform steps 4.3.1 through 4.3.9 below. To replace any other electrical part, perform steps 4.2.1 through 4.2.4 above, make the necessary replacement and reassemble the unit by performing those steps in the reverse order.

4.3.1 Perform steps 4.2.1 to 4.2.7 above.

4.3.2 Using a small (17.5W maximum) soldering iron, unsolder the thermistor leads from the solder lug and the circuit board.

4.3.3 Remove the two screws which secure the cable mounting bracket to the two spacers. Push the cable mounting bracket aside, and remove the two spacers.

4.3.4 Push the electrical caps back on the electrical contacts until the wires they secure come free. Remove the electrical caps and the helical compression springs.

4.3.5 Remove the screw and lockwasher which secure the circuit board and remove the board.

4.3.6 Carefully remove the retaining ring which secures the thermistor assembly and discard.

4.3.7 Withdraw the thermistor assembly, and its associated insulator and spring. Discard the defective thermistor assembly and its associated spring.

4.3.8 Perform the following step carefully ensuring that the replacement thermistor assembly is centred at all times in the rear heat sink assembly.

4.3.9 Install the replacement thermistor assembly using the old insulator and the new spring and retaining ring.

4.3.10 Reassemble the unit by performing the above steps in the reverse order. Either thermistor lead can be connected to the circuit board.

Chapter 4

Maintenance

4.4 CALIBRATION

To recalibrate the tft Power Head as part of a periodic calibration programme, it is acceptable to use either of the two procedures which follow.

If the r.f. procedure is employed, a frequency of 1 GHz or less is best so that mount efficiency errors can be ignored.

4.4.1 R.F. Calibration

With an r.f. standard, a known level of power from a well-matched source (VSWR less than 1.02) should be established. A 500 mW level is best to minimize drift and noise. It is acceptable, however, to use a reduced level as low as 100 mW if the 500 mW level is not available. The VSWR of the tft Power Head should be measured at the calibration frequency and the return loss computed. With the tft Power Head connected to the Model 6460 and the efficiency control set to 100, apply the r.f. signal and adjust the calibration potentiometers R3 (see Fig.4) to produce the desired reading including correction for the return loss. The calibration potentiometer is available at the rear of the Power Head housing by removing the metal plug under the notation CAL.

4.4.2 Audio Calibration

(a) Connect the tft Power Head as shown in Fig.3. Be sure to observe proper ground connections to avoid spurious ground loops. To check for this, prior to connecting the tft Power Head observe the d.c. voltmeter as the a.c. generator output is varied. There should be no reading under these conditions. Disconnect the d.c. voltmeter and observe that there is no change in the a.c. voltmeter reading.

(b) Adjust the output of the 1 kHz generator to approximately 14.25V. Measure the r.m.s. audio input voltages (E and E_L) and the d.c. output voltage $E_{d.c.}$.

Then turn off the audio generator and promptly measure the resistance between pins 2 and 9 (R_s). Compute the sensitivity (S) as follows:

$$S = \frac{E_{d.c.}}{\frac{(E - E_L)}{200}\left[E_L - \frac{1.5(E - E_L)}{200}\right]}$$

Compute the required value for the calibration resistance from the formula:

$$R = \frac{100R_s}{100 + R_s}(4638S - 1)$$

where S is in volts per watt and R_s is in ohms.

Connect a precision resistance bridge between pins 8 and 9 of P1 and adjust R3 to produce the desired resistance.

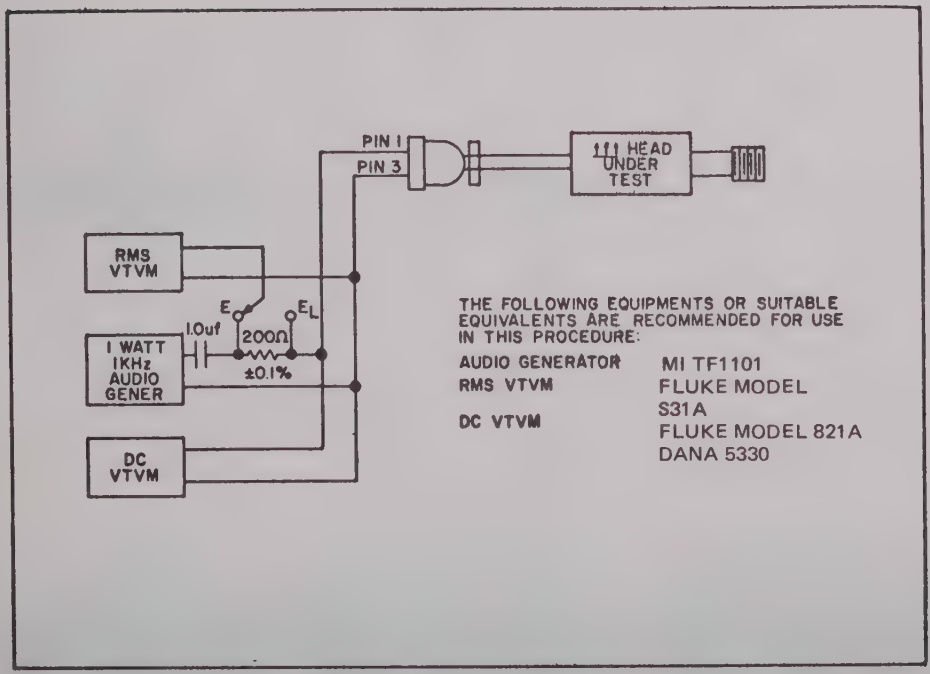


Figure 3. Test set up for Audio Calibration

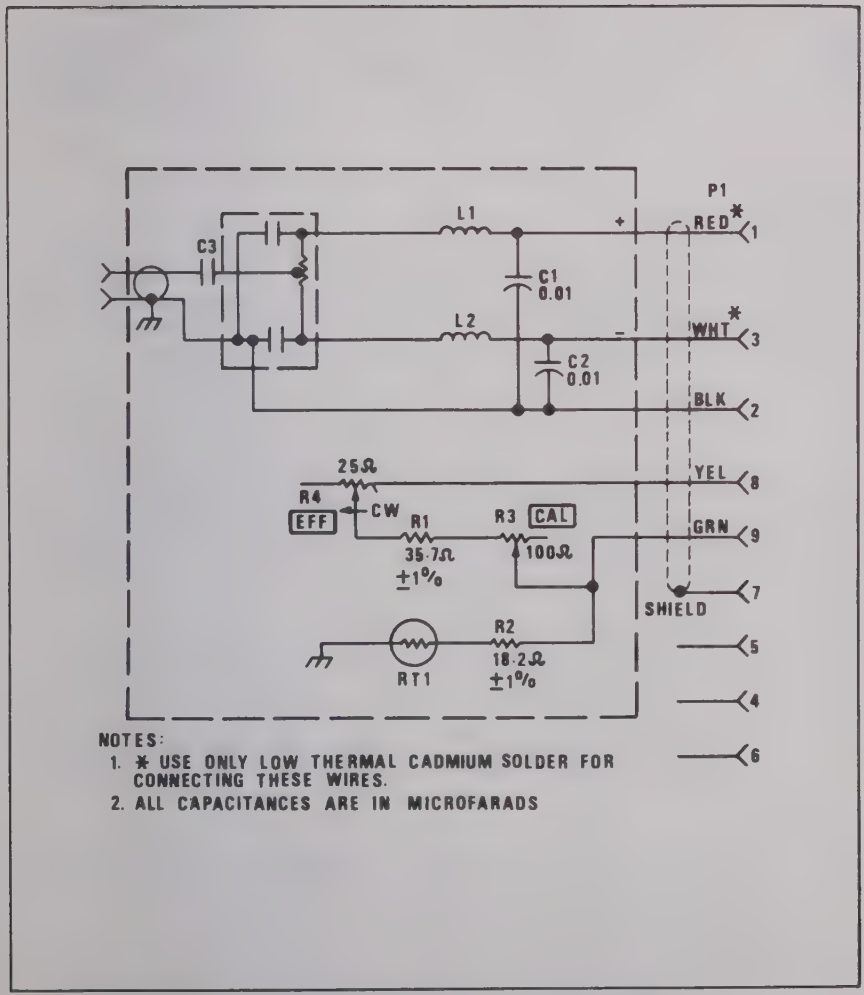


Figure 4. Schematic Diagram Type 6423

4.4.3 Efficiency Determination

For recalibration when replacing tft elements, the mount should first be tested in accordance with the audio calibration procedure described in 4.4.2. R.F. effective efficiency can then be determined by measurement against r.f. standards and the new efficiency factor marked on a new calibration plate and attached to the mount.

4.4.4 Calibration with Extension Cables

When using tft Power Heads in conjunction with extension cable assemblies, such as MI/Sanders Type W967, W970 and W972, it is necessary to compensate for the resistance of the extension cable assemblies. Towards this end, it is acceptable to use any of the methods given below. (If the total length of the extension cable assemblies does not exceed 10 ft, the resistance can be ignored.)

(a) Perform either the 4.4.1 or the 4.4.2 procedures described in this literature with the extension cable assemblies attached to the tft Power Head.

(b) Perform the described audio-calibration procedures and change the calibration formula in equation (1) and (2) as necessary from R = ( ) to R = ( ) −X where X = the resistance of the cable assemblies at 1 ohm per 20 ft.

(c) Perform the described r.f. calibration procedures and adjust the CAL potentiometer X ohms lower (see 2 above) than the value to which it would normally be adjusted. Make this adjustment at the conclusion of the described procedures.

4.5 ACCESSORIES AVAILABLE

Tool Kit 3850 – TK-1 consisting of:

A. Assy. Jig	C. Tweezers
B. Screwdriver	C. Allen Key

Chapter 5

Replaceable parts

Ref. Sym.	Description	Part No.	Mfr.	Quantity Used per Article
				6423
–	Cover Sheet*	–	MI/S	1
–	Cable Sp. Elec.	3853/119	MI/S	2 m
–	Dial	3856/016	MI/S	1
–	Calibration Plate*	–	MI/S	1
C1, C2	Capacitor, Fxd. Ceramic; 0.01 μf ±20%, 100V	–	Comm.	2
C3	Capacitor, Fxd. Ceramic (Part of centre conductor assembly)	3853/115	MI/S	1
L1, L2	Choke, RF, Fxd.	3853/126	MI/S	2
P1	Conn. Plug, Elec.	3853/120	MI/S	1
R1	Res. Fxd. Film 35.7Ω ±1%	M125	MANN	1
R2	Res. Fxd. Film 18.2Ω ±1%	M125	MANN	1
R3	Res. Var. WW 100Ω	84–3–8–101	Spectrol	1
R4	Res. Var. WW	3853/012	MI/S	1
RT1	Thermistor Assembly	3856/026	MI/S	1
–	tft Element	TL–3	MI/S	1

* Supplied with each replacement tft element

COMM–Common Part available from a number of manufacturers.

ADDENDUM TO OPERATING INSTRUCTIONS.
M.I. SANDERS tft POWER HEADS
LOW FREQUENCY VERSIONS

This addendum, when used with this handbook provides all the required data for the above versions.

The performance of the low frequency tft power head is the same as the corresponding standard version except that it has been modified to operate over the frequency range with VSWR Specification as shown below.

	6423/11 3 W
VSWR at 500KHz	1.5
VSWR between 2MHz – 1GHz	1.2

	6423/12
VSWR at 10KHz	1.5
VSWR between 2MHz – 1GHz	1.2

Modifications which affect the circuit diagram and replaceable parts list are as follows:-

	6423/11
R1	60.4ohm
C3,C4,C5. MISD. Pt. No.	3867104

	6423/12
R1	60.4ohm
C3,C4,C5. MISD. Pt. No.	3868104

1. The effective efficiency potentiometer R4 has been deleted on all the heads mentioned in this addendum.
2. C4 and C5 are fitted in parallel with each of the two capacitors which are shown in the area identified as tft element in fig. 4.

TO ORDER REPLACEMENT ELEMENT KIT, STATE THE tft POWER HEAD TYPE NUMBER TO ENSURE CORRECT REPLACEMENT.

808/04671

Printed by The Marconi Reprographic Services Group Chelmsford

MARCONI INSTRUMENTS LIMITED,
SANDERS DIVISION
P.O. BOX No. 10
GUNNELS WOOD ROAD
STEVENAGE, HERTS., ENGLAND
SG1 2AU

MP MASTER
MA23609

Telephone: Stevenage 2311
Telex: 82159
Telegrams: 'Sandelect' Stevenage